The Chromodoridinae Nudibranchs from the Pacific Coast of America. - Part II. The Genus *Chromodoris*

BY

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(3 Plates; Text figures 4 - 15)

THIS IS THE SECOND article in a 4-part series monographing the Chromodoridinae from the Eastern Pacific. Figures and tables are numbered consecutively through all 4 articles.

Part I (BERTSCH, 1977) consisted of Materials and Methods and supra-specific chromodorid taxonomy. In Materials and Methods, I examined the use of the radula in opisthobranch taxonomy by: 1) analyzing both the contribution of scanning electron microscopy (SEM) to radular studies (cf. also a recent paper by HICKMAN, 1977, which appeared too late for inclusion in Part I) and methods of specimen preparation for successive viewing by SEM and light microscopy; 2) discussing the numerical analysis of radular variation (see also BERTSCH, 1976a); and, 3) defining the structural terms applicable to radular teeth. The taxonomic coverage of Part I was at the levels of the family, subfamily and genus.

Chromodoris Alder & Hancock, 1855

Chromodoris baumanni Bertsch, 1970

(Figures 3-A, 4, and 10 - 12)

References and Synonymy:

Chromodoris norrisi (not Farmer, 1963). MARCUS & MARCUS, 1967: 170 - 173; fig. 24; Material 3

Chromodoris sp. BERTSCH, 1971: 16

Chromodoris baumanni Bertsch, 1970: 8 - 12; figs. 3 - 13 SPHON & MULLINER, 1972: 150 - 151. SPHON, 1972b: 59. BERTSCH, FERREIRA, FARMER & HAYES, 1973: 289, 292. BERTSCH, 1973: 108, 110. KEEN & COAN, 1975: 43. BERTSCH, 1976b: 157

Material Examined and Distribution:

Baja California, Mexico:

1) 1 specimen, Isla Carmen; *leg.* C. Gage, April 1974 (identified from a color transparency)

2) 3 specimens, 1 km north of Isla Monserrate; *leg.* A. J. Ferreira, 16 June 1974 (HB 377 A - C)

3) 1 specimen, La Paz area; *leg.* E. Janss, Jr., April 1972 (HB 398; LACM A-9555)

4) 1 specimen, 2 - 3 m subtidal, Bahía Carisalito, 4 km N of Bahía Las Cruces; *leg.* H. Bertsch, 23 July 1972 (HB 5)

5) 1 specimen. Isla Espíritu Santo; *leg.* W. M. Farmer, 29 June 1964 (identified from a color transparency)

6) 1 specimen, Isla Espíritu Santo; *leg.* E. Janss, Jr., April 1974 (HB 401; LACM A-9555)

7) 1 specimen, Isla Cerralvo; *leg.* W. M. Farmer, May 1962 (identified from a color transparency)

8) 2 specimens, intertidal to 6 m subtidal, Cabo Pulmo; *leg.* C. Gage *et al.*, 25-26 May 1971 (HB 386 A-B; LACM)

Mainland Mexico:

9) 1 specimen, 20 m subtidal Guaymas, Sonora; *leg.* A. Kerstitch, 12 March 1966 (HB 321; USNM 753559)

10) 2 specimens, intertidal, Sayulita, Nayarit; *leg.* G. G. Sphon, January 1970 (HB 397 A-B; LACM 70-4)

11) 3 specimens, intertidal, Punta Mita, Nayarit; *leg.* F. & R.Poorman, 2 January 1976 (HB 416 A-C; LACM A-8477)

South America:

12) 1 specimen, Academy Bay, Santa Cruz Island, Galápagos Islands; *leg.* A. G. Smith, February 1964 (identified from a color transparency)

13) 1 specimen, intertidal, Academy Bay, Santa Cruz Island, Galápagos Islands, *leg.* Ameripagos Expedition, March 1971 (HB 400; LACM 71-44)

Type Locality:

The type locality of *Chromodoris baumanni* is Isla San Francisco, Baja California; previous collecting records of this species include the Gulf of California, southern Mexi-

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Editor's Note: For Figures 3-A, 3-B, etc. see The Veliger 20 (2): 115

co, Central America, and the Galápagos Islands. Its northernmost reported occurrence is Bahía San Carlos, Sonora, Mexico (Bertsch *et al.*, 1973).

External Morphology and Coloration:

Chromodoris baumanni reaches at least 62 mm in total length. Notal and foot background color is white; in the notal dorso-median region this background color is light yellow. Numerous small red-purple dots cover the notum and the posterior and lateral surfaces of the foot. An interrupted band of orange (or light red) dots and streaks surrounds the lateral edges of the notum and foot. The rhinophores are white, with a red-purple coloration distally; the extreme tip is white. The gills are white, with a purplish hue on the distal portion (cf. the color illustrations in Bertsch, 1970: figs. 3 - 6).

Radula:

Sizes of each radula examined, the respective width: length ratio, number of tooth rows and maximum number of teeth per half-row are given in Table 1. The combined radular formula (including literature references) is 47 - 84 rows with 29 - 68 teeth per half-row; rachidian tooth absent.

Least squares regression line analysis shows that the number of rows of teeth and the maximum number of teeth per half-row are positively correlated (Figure 10-A). The coefficient of correlation (r) is 0.949 ($n = 16$, $P < 0.001$). The regression line is described by the equation $Y = -11.09 + 0.922\ X$.

The number of rows is positively correlated with the length of the radula (Figure 11-A). The regression line formula is $Y = 37.96 + 11.228\ X$; $r = 0.922$, $n = 14$, and $P < 0.001$.

The maximum number of teeth per half-row is dependent upon the width of the radula (Figure 12-A). The equation, $Y = 24.52 + 19.674\ X$, describes the regression line and the coefficient of correlation equals 0.8808, $n = 14$, $P < 0.001$.

Figure 4-A presents an outline sketch of a flat-mounted radula. The innermost lateral tooth (Figure 4-B) has 3 - 4 denticles on the inner face, and 2 - 6 (usually 3 - 5) denticles on the outer face. The inner lateral teeth (approximately the first 5 - 10) are short, with a strongly recurved shaft and a proportionately long base; the cusp is much longer than the succeeding denticles (Figures 4-C - 4-G). Throughout the middle of the half-row, the teeth (Figures 4-H, 4-I) have a longer, straighter shaft, with 6 - 9 denticles on the posterior surface. The denticles are larger in size relative to the cusp.

The length of the cusps (measured on a straight line, from the notch joining the first denticle with the cusp,

Table 1

Radular variation in *Chromodoris baumanni*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
1	—	—	—	82	65
2	—	—	—	84	64
5	1.99	1.13	1:1.77	53	41
321	3.33	1.82	1:1.83	85	68
377 A	2.99	1.66	1:1.8	74	55
377 B	2.81	1.58	1:1.78	70	55
377 C	3.29	1.86	1:1.77	67	54
386 A	3.76	1.58	1:2.38	80	67
386 B	3.64	1.92	1:1.89	78	55
397 A	1.27	0.57	1:2.23	59	34
397 B	0.85	0.46	1:1.85	47	31
398	2.26	1.13	1:2	64	55
401	1.52	0.75	1:2.03	49	37
416 A	1.18	0.53	1:2.23	55	42
416 B	0.92	0.36	1:2.56	48	29
416 C	1.58	0.85	1:1.86	55	39
$\overline{X}$	2.24	1.16	1:1.99	65.625	49.438
s	1.045	0.572	0.254	13.657	13.261

[1]Marcus & Marcus, 1967; [2]Bertsch, 1970

to the tip of the cusp) averaged 0.0086 mm (range, 0.005 - 0.013 mm, n = 26) for the inner 15 lateral teeth and random teeth from the middle of the half-row. The mean ratio of the length of the first denticle to the length of the cusp is 1 : 1.79 (range, 1.2 - 3.25; s = 0.457; n = 27). The outermost lateral teeth (Figures 4-J, 4-K) become smaller, with cusp and denticles greatly reduced in size.

Developing teeth (Figures 4-L - 4-O) show earliest development of the base and shaft, with minute denticles. Denticles begin growth as small points on the future posterior surface of the tooth. After initial formation, growth

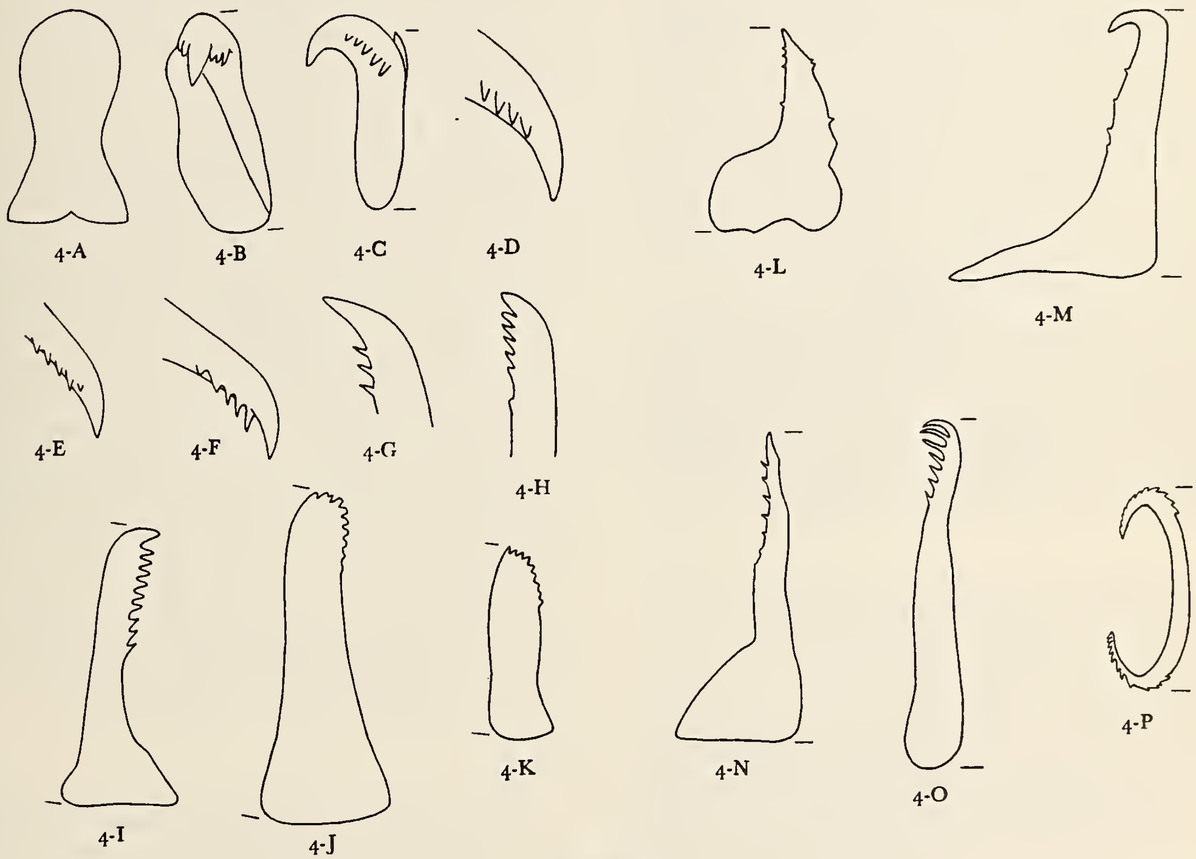


Figure 4

Radular teeth of *Chromodoris baumanni*

A – HB 398; outline sketch of entire radula

B – HB 5; innermost lateral tooth, approximately row 17, right side of radula (RSR); length between marks (LBM) 0.059 mm

C – HB 5; postero-lateral view of 2nd lateral tooth, row 40, RSR; LBM, 0.053 mm

D – HB 398; distal portion of shaft, 2nd lateral tooth, row 55, left side of radula (LSR)

E – HB 398; distal portion of shaft, 3rd lateral tooth, row 55, LSR

F – HB 398; distal portion of shaft, 7th lateral tooth, row 55, LSR

G – HB 386 A; distal portion of shaft, 11th lateral tooth, row 37, RSR

H – HB 398; distal portion of shaft, 26th lateral tooth, row 21, RSR

I – HB 5; tooth from middle of half-row, approximately row 42, LSR; LBM, 0.081 mm

J – HB 5; second outermost tooth, approximately row 42, LSR; LBM, 0.079 mm

K – HB 5; outermost tooth, approximately row 40, LSR; LBM 0.055 mm

L – HB 398; developing 1st lateral tooth, row 64, RSR; LBM 0.03 mm

M – HB 398; developing 5th lateral tooth, row 64, RSR; LBM, 0.039 mm

N – HB 398; developing 10th lateral tooth, row 64, RSR; LBM, 0.071 mm

O – HB 398; developing 36th lateral tooth, row 64, RSR; LBM, approximately 0.12 mm

P – Monaxon sponge spicule (with recurved ends) found under the shafts of lateral teeth in *Chromodoris baumanni* (HB 377-C) radula; LBM, approximately 0.24 mm

proceeds by thickening and enlarging of the various tooth parts.

In the original description of this species, BERTSCH (1970: figs. 7 - 10) presented scanning electron micrographs of the radular teeth.

Discussion:

Chromodoris baumanni is closely related to *C. norrisi*. Differences between the 2 species will be analyzed under *C. norrisi*. *Chromodoris baumanni* also shows similarities with the Hawaiian *C. lilacina* (Gould, 1852), but the colorations and radular morphologies of these species fall outside each other's range of variation. The rhinophores and gills of *C. lilacina* are orange-yellow or straw-colored (KAY & YOUNG, 1969: 202), distinct from the reddish-purple hues of *C. baumanni*; *C. lilacina* has proportionately fewer teeth per half-row (relative to the number of tooth rows) than does *C. baumanni*.

Feeding habits of *Chromodoris baumanni* are not known; a sponge spicule (Figure 4-P) was lodged beneath the tooth shafts of one radula. The cusp and denticle morphology of the radular teeth are primarily adapted for scraping across sponge tissue, but the teeth can also hook the curved ends of such C-shaped spicules and extract more tissue adjacent to the spicule.

Chromodoris ***galexorum*** Bertsch, spec. nov.

(Figures 3-B, 5, 10 - 12, *33* - *36*)

Material Examined and Distribution:

Gulf of California, Mexico:

1) Holotype. 17m subtidal, under a ledge, Isla San Pedro Martir, Sonora, Mexico (approximately 28°22'N; 112° 20'W); *leg.* A. Kerstitch, 16 June 1976 (HB 467 B). This dissected specimen and its mounted radula have been deposited in the collections of the Los Angeles County Museum of Natural History, LACM Type Series, No. 1848.

2) Paratypes. 2 specimens, 17m subtidal, under a ledge, Isla San Pedro Martir; *leg.* A. Kerstitch, 16 June 1976 (HB 467 A, D). Water temperature at depth collected, 22.3°C

3) 1 specimen, 12m subtidal, in a dark cave, Isla San Pedro Nolasco, Sonora, Mexico (approximately 27°58'N; 111° 22'W); *leg.* A. Kerstitch, 22 June 1976 (HB 467 C)

4) 2 specimens, subtidal, Guaymas, Sonora, Mexico; seen by A. Kerstitch, April 1972 (identified from a color transparency)

5) 1 specimen, La Paz area, Baja California; *leg.* E. Janss, Jr., April 1974 (HB 256)

The known occurrence of this new species is from subtidal localities in the central and southern Gulf of California. Isla San Pedro Martir is the type locality. Mr. A. Kerstitch (personal communication) states it is fairly common subtidally around Guaymas in the springtime. He collected an additional specimen of *Chromodoris galexorum* at Isla San Pedro Nolasco, in 15m of water, on 16 March 1977.

External Morphology and Coloration:

The lengths of 5 preserved specimens were 15, 16, 17, 22, and 24mm. The number of gills (usually more numerous in larger specimens) were 7, 10, and 16 in 3 specimens; rhinophore lamellae varied from 18 - 24.

The body background color is white. Scarlet spots occur on the dorsum, many of them being immediately surrounded by a chrome yellow ring. At times the yellow coloration is present also as small splotches within the scarlet. The scarlet spots are largest down the midline of the dorsum. One specimen also had a transverse series of 3 larger spots (with overlapping edges) halfway between the rhinophores and the gills. The notal border is rimmed dorsally with a solid chrome yellow band. The lateral and posterior surfaces of the foot are white, with small scarlet dots scattered throughout; the sides of the foot can have 4 - 5 loose rows of these scarlet maculations. Except for yellow rings surrounding 2 or 3 scarlet spots on the midline of the postero-dorsal foot surface, there is no yellow coloration on the foot. The rhinophores and gills are scarlet, darker distally.

Whitish glands occur on the underside of the notal overhang. There are 6 - 7 per side of the body, and each consists of an ovalish structure that has 4 - 5 finger-like extensions protruding towards the animal's body.

Radula:

Meristic data of 5 radulae are found in Table 2. The range of variation of the radular formula is 56-59 (47-57 · 1 · 47-57). The number of teeth per half-row is only slightly less than the number of rows. There were too few specimens available to perform regression analyses on radular characteristics; the points of the radular parameters are graphed in Figures 10 - 12.

The radular teeth have the typical unicuspid *Chromodoris* shape: inner laterals have shorter shafts with denticles on the outer face (Figure *34*), followed by longer shafted teeth in the middle of the half-row that show denticulation on the posterior surface (Figures *35*, *36*).

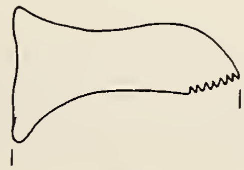
A triangular rachidian tooth is present (Figures 5-A, *33*), with an elevated central cusp. The innermost lateral tooth (Figures 5-A, *33*) has 3 - 4 denticles on the inner face, 5 - 6 on the outer face. Denticles increase in number on each tooth towards the middle of the half-row, where there are usually 15 - 18 denticles on the posterior surface. Scanning electron micrographs cannot be used to count

Table 2

Radular variation in *Chromodoris galexorum*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
256	–	1.37	–	–	53
467 A	3.21	1.64	1:1.96	57	52
467 B	2.87	1.56	1:1.84	56	47
467 C	3.11	1.92	1:1.62	59	49
467 D	3.88	2.24	1:1.73	59	57
$\overline{X}$	3.27	1.75	1:1.79	57.75	51.6
s	0.433	0.34	0.146	1.5	3.847

5-A



5-B

Figure 5

Radular teeth of *Chromodoris galexorum* Bertsch, spec. nov.
A – HB 256; rachidian tooth and 1st lateral tooth drawn in relative position to each other, row 11, LSR; LBM, 0.071 mm; rachidian 0.028 mm long
B – HB 256; lateral tooth 52, row 11, LSR; LBM, 0.071 mm

denticles routinely, since overlapping teeth in the field of view obscure parts of teeth behind them. Denticular counts must be verified with the light microscope.

Lengths of tooth cusps ranged from 0.012 - 0.024 mm, with a mean of 0.019 mm ($n = 21$). The cusp of each tooth averages 5.05 times as long as the first denticle ($n = 21$; range is 3 - 7; $s = 1.073$). The outermost 4 - 5 teeth approach the first denticle length : cusp length ratio of 1 : 1; the cusp, denticles, and shaft length become markedly shorter (Figure 5-B).

It is of special note (with reference to the later discussion of *Chromodoris sphoni*) that in the last 8 radular rows of specimen HB 467 D, the inner 3 - 6 lateral teeth have a slight denticulation or ridging of 1 - 5 denticles on the inner face of the distal shaft area. These are in addition to the normal positioning of denticles on the outer face of the tooth shaft.

Discussion:

Chromodoris galexorum needs to be compared with Panamic chromodorids that exhibit a white notal background. It is immediately distinguishable from those species with dominant blue coloration. *Chromodoris baumanni* does not have a solid yellow band bordering the notum edge, but it has a broken orange or red band; moreover, it does not have bright yellow enclosing its red-violet spots. The spots of *C. baumanni* are also smaller and more regularly circular than the big, irregular red blotches of *C. galexorum*. *Chromodoris marislae* has yellow-orange circlets (some with open centers, others solid), with white surrounding the larger markings. *Chromodoris norrisi* has evenly circular markings of red and yellow, with a broken orange band around the notum. *Chromolaichma dalli* has black dots on its notum, and *Chromolaichma sedna* has a completely white notum with solid yellow and red bands around the periphery of the mantle.

Two Australian species appear similar to *Chromodoris galexorum*, but can be readily separated on the basis of coloration and radular morphology. The ranges of variation of the 3 species do not overlap. *Chromodoris daphne* (Angas, 1864) lacks yellow borders to the scarlet maculations, and has both yellow and red color bands surrounding the notum; it has proportionately shorter teeth cusps

and fewer denticles on the shafts of the teeth than *C. galexorum* (the teeth of *C. daphne* are illustrated in THOMPSON, 1972: figs. 3i, 3j, 3k). *Chromodoris splendida* (Angas, 1864) also lacks yellow rimming the scarlet maculations; in large specimens, the scarlet spots are highly irregular blotches, often fusing into a thick reticulating pattern. The teeth of *C. splendida* have fewer denticles (cf. THOMPSON, *op. cit.*: plt. 2d, figs. 2k - 20) than *C. galexorum*; the outer teeth, not reduced in size, have thin erect shafts devoid of denticles (THOMPSON, *op. cit.*: plt. 2 c). Thompson also presents color drawings of living *C. daphne* and *C. splendida.*

Etymology:

The specific name *galexorum* is chosen as an acronym of Gale and Alex, to honor Mr. Gale Sphon (Los Angeles County Museum of Natural History) and Mr. Alex Kerstitch (Tucson, Arizona), who provided me with specimens of this new species.

Chromodoris marislae Bertsch, *in* BERTSCH, FERREIRA, FARMER & HAYES, 1973

(Figures 3-C, 6, 13 - 15)

References:

BERTSCH, FERREIRA, FARMER & HAYES, 1973: 289 - 292; figs. 1 - 11. BERTSCH & FERREIRA, 1974: 344. KEEN & COAN, 1975: 45

Material Examined and Distribution:

Baja California, Mexico:

1) 1 specimen, Guaymas, Sonora; *leg.* A. Kerstitch, April 1972 (identified from a color transparency)
2) 1 specimen, Los Islotes; *leg.* A. J. Ferreira, September 1971 (HB 370)
3) 5 specimens, La Paz area; *leg.* E. Janss, Jr., April 1972 (HB 34 A-E)

The known distribution of *Chromodoris marislae* had been limited previously to localities along the Baja California Gulf coast, between Isla Santa Catalina (type locality) and La Paz. The Guaymas record is the first report from the coast of mainland Mexico, and constitutes a northward range extension of over 230 km. The specimens from La Paz are part of Lot 4 of the original description.

External Morphology and Coloration:

Living *Chromodoris marislae* reach 80 mm in total length (BERTSCH *et al.*, 1973). Body color is an off-white, with 2 or 3 irregular rows of orange spots encircling the periphery of the notum; centrad to these rows is a roughly circular arrangement of larger orange ringlets, which are often surrounded or marked centrally with a pure white coloration. The bases of the rhinophores have almost a translucent quality, and the distal end is light brown; there is a prominent median white longitudinal septum on both its anterior and posterior faces. The gills are also light brown, with pure white on the center of each branching of the gills (color photographs of *C. marislae* are in BERTSCH *et al.*, *op. cit.*: figs. 1, 2).

Radula:

The radular formula varies from 59-82 (53-70·1·53-70). Meristic data for 8 radulae are presented in Table 3.

The number of rows and the maximum number of teeth per half-row are positively correlated (Figure 13); $Y = 20.56 + 0.6039\,X$; $r = 0.9005$, $n = 8$, $P < 0.01$.

Table 3

Radular variation in *Chromodoris marislae*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
34 A	5.07	2.99	1:1.69	76	70
34 B	4.14	2.26	1:1.83	60	57
34 C	3.9	2.3	1:1.7	58	54
34 D	3.66	2.02	1:1.81	60	59
34 E	4.71	2.16	1:2.18	82	68
370	4.59	2.3	1:1.99	77	67
Holotype[3]	–	–	–	59	59
Paratype 2[3]	–	–	–	62	53
$\bar{X}$	4.35	2.34	1:1.87	66.75	60.875
s	0.535	0.3366	0.188	9.8	6.578

[3]BERTSCH *et al.*, 1973

A positive correlation exists between the length of the radula and the number of rows (Figure 14). The regression line formula is $Y = -6.27 + 17.28\ X$, $r = 0.8691$ ($n = 6$, $P < 0.01$).

Because of the small sample size, no correlation could be proven statistically between the radular width and the maximum number of teeth per half-row ($r = 0.5001$, $P > 0.1$). The parameters are simply plotted in Figure 15.

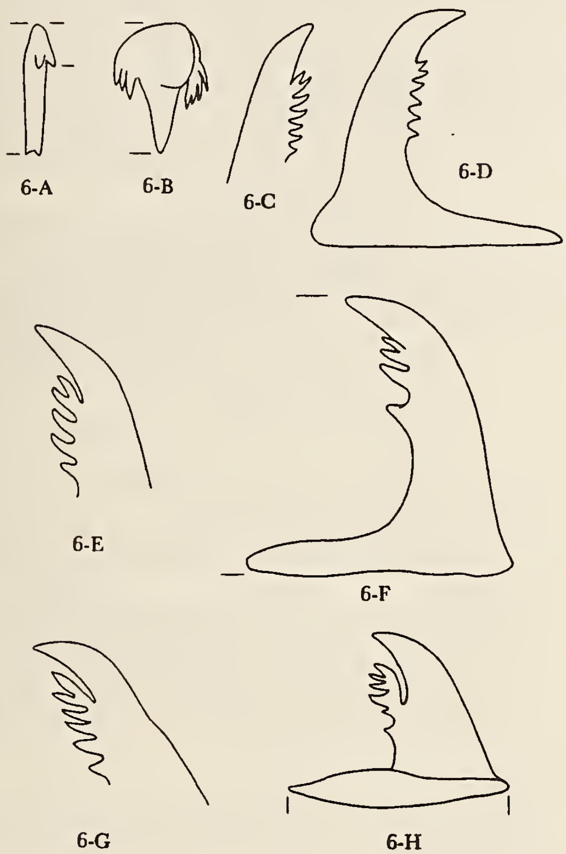


Figure 6

Radular teeth of *Chromodoris marislae*

A – HB 34 C; rachidian tooth, row 13; LBM, left side 0.04 mm, right side, 0.014 mm

B – HB 370; dorsal view of cusp of innermost lateral tooth, posterior portion of radula; LBM, 0.032 mm

C – HB 34 A; distal portion of shaft of lateral tooth 19, row 17

D – HB 34 B; lateral tooth 28, row 21, LSR

E – HB 370; distal portion, shaft of 8th lateral tooth from outer edge, row 30, RSR

F – HB 370; 6th tooth from outer edge, row 30, RSR; LBM 0.053 mm

G – HB 370; 4th tooth from outer edge, row 30, RSR

H – HB 370; 3rd tooth from outer edge, row 30, RSR; tooth is tilted, and foreshortened shaft is not parallel with plane of focus; LBM, 0.057 mm

The rachidian tooth (Figure 6-A) has a long base, and a bifurcated, erect cusp. There are 3 - 4 denticles on both the inner and outer faces of the innermost lateral tooth (Figure 6-B). The denticles increase in number from the center of the radula to the middle of each row, and then decrease towards the outermost teeth. For example, row 41 (left side of radula, HB 34 B) has 3 denticles on the outer face of each of the first 13 lateral teeth, 4 - 5 denticles on the posterior surfaces of the next 10 teeth, 5 - 7 on each of the succeeding 20, and 5 - 3 denticles on each of the outermost 14 teeth. The innermost laterals are not smooth (contrary to the statement in Bertsch *et al.*, 1973: 290), but are denticled on the outer face. Figure 8 of Bertsch *et al.* is a view of the inner face of an innermost lateral, and denticles are not visible because of the non-transparency of teeth in scanning electron micrographs.

The teeth of *Chromodoris marislae* are large, with solid cusps and fairly large denticles. The cusp lengths of the inner 36 teeth of row 20 (HB 34 B) varied from 0.02 - 0.032 mm ($\overline{X} = 0.027$ mm). The reduced size of the outermost lateral teeth is accompanied by reduced cusp and denticle size. The outer 10 teeth had cusp lengths of 0.02 - 0.01 mm ($\overline{X} = 0.016$ mm). In this same row, the cusps averaged 2.26 times longer than the denticles (range, 1.25 - 3.2, $s = 0.449$, $n = 46$).

Quite a few of the lateral teeth show a unique specific denticulation pattern (Figures 6-C to 6-H). The first 2 denticles below the cusp are united from a common base, giving the appearance of bifurcating. Although this is not universal, it appeared often enough on each of the radulae examined to be considered diagnostic. This condition was illustrated by Bertsch *et al.* (1973: figs. 5 A, B, D, E) but they did not comment upon its occurrence.

Scanning electron micrographs of *Chromodoris marislae* radular teeth are in Bertsch *et al.*, 1973.

Discussion:

The current records of *Chromodoris marislae* are all from subtidal locations; increased SCUBA research in the Gulf of California should yield more specimens.

Chromodoris mcfarlandi Cockerell, 1901

(Figures 3-D, 7, 13 - 15, *37 - 40*)

References and Synonymy:

Chromodoris mcfarlandi Cockerell, 1901: 79 - 80. Cockerell, 1902: 20 - 21. Bertsch, 1976b: 157 - 158

Glossodoris macfarlandi (Cockerell). O'Donoghue, 1926: 212. O'Donoghue, 1927: 89 - 90, 116; plt. 2, figs. 33 - 37. Pruvot-Fol, 1951a: 120. Pruvot-Fol, 1951b: 152. Lance, 1961: 66. Paine, 1963: 4, 7, 8. Farmer & Collier, 1963: 62. Steinberg, 1963:69. MacFarland, 1966: 153 - 157; plt. 22, figs. 1 - 5; plt. 34, figs. 1 - 11. Sphon & Lance, 1968: 79. Ricketts & Calvin, 1968: 119, 514. McBeth, 1970 (not seen; *fide* Bloom, 1976). Abbott, 1974: 354, fig. 4239. Bloom, 1976: 292 - 294

Chromodoris macfarlandi Cockerell. Cockerell & Eliot, 1905: 36. MacFarland, 1906: 129. Cockerell, 1908: 106. Johnson & Snook, 1927: 494; plt. 11, fig. 2. Marcus & Marcus, 1967: 178. Roller & Long, 1969: 425, 429. Lance, 1969: 37. Roller, 1970a: 371. Roller, 1970b: 482. Long, 1970: 19. McBeth, 1971a: 28. Keen, 1971: 822; Schmekel, 1972: 194. Sphon, 1972: 59. Bertsch *et. al.*, 1973: 287. Smith & Carlton, 1975: 528, 538; plt. 121, fig. 6. Keen & Coan, 1975: 43 (# 2330)

The correct date of authorship, as O'Donoghue (1927: 89) showed, is 1901. The description published 28 November 1901 has priority over Cockerell's intended new species description published June 1902.

The spelling of the specific name requires comment. Cockerell's original spelling was a misspelling of MacFarland's name. The species name occurs once in his 1901 paper and once in his 1902 article, both times as *Chromodoris mcfarlandi.* In acknowledging the patronym, Cockerell (1902: 21) wrote, "Named after Prof. F. M. McFarland [sic] of Stanford University, who has done some excellent work on the nudibranchs of Pacific Grove, California." Cockerell was clearly in error on the proper spelling of Dr. MacFarland's name.

The rules of zoological nomenclature provide that the original spelling of a species name is to be retained as the correct spelling unless it contravenes certain mandatory provisions or there is clear evidence in the original publication that an inadvertent error (*lapsus calami*, copyist's or printer's error) has occurred (Mayr, 1969: 312 to 313; 355 to 356). The evidence is to the contrary. Both of Cockerell's papers misspelled MacFarland (including the patronymic designation), and there are no multiple spellings in the original 1901 paper (nor in the 1902 paper). Repetition of the error in 2 different papers submitted to 2 separate journals, makes it highly unlikely that a slip of the pen or a printer's error occurred. There is no clear evidence of an inadvertent error (in the sense of the Code), and no contravention of mandatory provisions. Therefore, the spelling of *C. macfarlandi* is an unjustified emendation and a junior objective synonym of the original *C. mcfarlandi.*

Material Examined and Distribution:

California and Offshore Islands:

1) 1 specimen, subtidal, off Monterey breakwater; *leg.* R. Ames, January 1963 (HB 458; CAS)

2) 2 specimens, Monterey Bay; *leg.* F. M. MacFarland, December 1908-January 1909 (HB 453 A-B; CAS)

3) 1 specimen, 22 m subtidal, off Del Monte, Monterey Bay; *leg.* S. S. Berry (no date) (CAS)

4) 2 specimens, Pacific Grove; *leg.* F. M. MacFarland, June 1908 (HB 454 A-B; CAS)

5) 1 specimen, Point Pinos, Monterey; *leg.* R. Page, 12 July 1941 (HB 455; CAS)

6) 1 specimen, 24 m subtidal, north end San Jose Creek Beach (36°32′N; 121°56′W); *leg.* J. McLean, 9 July 1971 (HB 393; LACM 60-24)

7) 1 specimen, intertidal, White's Point, Palos Verdes Peninsula (33°43′N; 118°18′W); *leg.* G. G. Sphon, 9 December 1969 (HB 396; LACM 69-37)

8) 2 specimens, Newport Bay; *leg.* G. E. MacGinitie, June 1948 (HB 457 A-B; CAS). These are the specimens drawn on plt. 22, figs. 1 - 5, of MacFarland, 1966

9) 2 specimens, Corona del Mar; *leg.* G. E. MacGinitie, 25 June 1948 (HB 456; CAS)

10) 1 specimen, La Jolla; *leg.* T. D. A. Cockerell, 1902 (HB 452; CAS)

11) 1 specimen, Isthmus, Santa Catalina Island; *leg.* A. J. Ferreira, 9 July 1975 (HB 361)

12) 1 specimen, intertidal, Catalina Harbor, Santa Catalina Island; *leg.* G. G. Sphon, 7 March 1970 (HB 392; LACM 70-8)

13) 1 specimen, 23 - 29 m subtidal, upper reef of Farnsworth Bank, Santa Catalina Island (33°21′N; 118°31′W); *leg.* C. Turner, 1-2 June 1970 (HB 394; LACM 70-74)

14) 1 specimen, 27 - 34 m subtidal, northwest of Pyramid Head, San Clemente Island; *leg.* C. Swift, 1 July 1971 (HB 395; LACM A 9325)

Mexico:

15) 3 specimens, 21 - 24 m subtidal, Isla Coronado (31°48′ N; 116°48′W); *leg.* A. J. Ferreira, 28 September 1973 (HB 253)

16) 1 specimen, intertidal to 11 m subtidal, Man-of-War Cove, Bahía Magdalena (24°37.5′N; 112°7.5′W); *leg.* J. McLean and P. LaFollette, 31 October 1971

The original material used by Cockerell was collected from La Jolla and San Pedro.

The reported range of *Chromodoris mcfarlandi* has been from Monterey to the Isla Cedros area, Baja California (Keen, 1971: 822). The specimen collected at Bahía Magdalena represents a southern range extension of over 480 km. Despite this new record at the northern boundary of the Panamic faunal province (tropical West America), Keen & Coan (1975: 43) were correct in con-

sidering *C. mcfarlandi* a member of the temperate and cooler water Californian and southern Oregonian marine provinces (*sensu* VALENTINE, 1966, and 1973: 351 - 356). This new record of *C. mcfarlandi*, while representing a true "range extension," is not indicative of the normal occurrence of this species. It is a thermally anomalous record (ZINSMEISTER, 1974) on the extreme periphery of the species' range.

Chromodoris mcfarlandi has also been reported from San Luis Obispo County, Santa Barbara County, Laguna Beach, Santa Catalina Island (California), and Isla Coronado (Mexico).

Lot 14 represents a new subtidal bathymetric range.

External Morphology and Coloration:

Living *Chromodoris mcfarlandi* are reported to reach 50 - 60 mm in length (JOHNSON & SNOOK, 1927: 494), but more commonly will vary in length up to 35 mm (MACFARLAND, 1966: 156).

Overall body color a brilliant reddish-violet. A yellow line runs down the center of the notum, from just anterior to the rhinophores to the forward edge of the gill pocket; an additional yellow line begins postero-laterally to each rhinophore, runs lengthwise along the animal's body, and joins behind the gills. A longitudinal yellow line is on the dorso-posterior foot surface. The notum is rimmed by narrow yellow and white bands (color photograph in LANCE, 1969: 37). MACFARLAND (1966: 155) also described slight yellow markings on the posterior surface of the foot and on the notum posterior to the gills.

Radula:

Although *Chromodoris mcfarlandi* was named over 75 years ago, there are published descriptions of only 2 radulae. O'DONOGHUE (1927: 90) reported about 62 rows of teeth, with about 50 teeth per half-row, and MACFARLAND (1966: 155) gave a radular formula of 62 (47-50 · 1 · 47-50). These reports indicate little of the vari-

Table 4

Radular variation in *Chromodoris mcfarlandi*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
4	—	—	—	62	50
5	—	—	—	62	50
253 A	1.51	0.48	1:3.15	46	32
253 B	1.43	0.51	1:2.8	41	27
253 C	1.11	0.69	1:1.61	41	32
361	1.66	0.63	1:2.63	41	30
392	0.87	0.32	1:2.72	41	23
393	2.95	1.56	1:1.89	76	49
394	2.55	1.03	1:2.48	57	50
395	1.76	0.73	1:2.41	44	32
396	0.78	0.32	1:2.44	36	16
452	1.72	0.83	1:2.07	50	34
453 A	1.818	0.808	1:2.25	51	38
453 B	1.66	0.67	1:2.48	56	—
454 A	1.39	0.65	1:2.14	46	32
454 B	1.68	0.73	1:2.3	48	31
456 A	2.1	1.01	1:2.08	52	36
456 B	1.94	1.05	1:1.85	51	34
457 A	1.66	1.01	1:1.64	43	36
457 B	1.64	0.909	1:1.8	60	35
458	2.1	1.05	1:2	52	43
$\overline{X}$	1.7	0.789	1:2.249	50.286	33.89
s	0.515	0.297	0.412	9.482	8.123

[4]O'DONOGHUE, 1927; [5]MACFARLAND, 1966

ability of the radular teeth counts. Table 4 gives the sizes, rows and teeth counts for 21 radulae. The combined radular formula is 36-76 (16-50 · 1 · 16-50). MacFarland and O'Donoghue examined specimens at the upper size range of the species. Their data were used by BLOOM (1976: 292) in his significant study correlating predator-prey morphology of dorid nudibranchs and sponges. His "radular mean" column, however, should not be used uncritically. The mean of *C. mcfarlandi* is given as 62 (49 · 0 · 49). The 49 is based on only the numbers (47, 50, 50) given by O'Donoghue and MacFarland, and contrasts sharply with the mean number of maximum teeth per half-row (33.89) that I calculated based on many more specimens. *Chromodoris mcfarlandi* possesses a rachidian tooth.

The expected positive correlation exists between the number of tooth rows and the maximum number of teeth per half-row (Figure 13). The regression line formula is $Y = -4.47 + 0.799X$; $r = 0.8421$, $n = 20$, $P < 0.001$.

The number of tooth rows is dependent on radular length (Figure 14). The regression line formula is $Y = 24.12 + 14.65\,X$; $r = 0.8283$, $n = 19$, $P < 0.001$.

The maximum number of teeth per half-row is dependent on the radular width (Figure 15). The regression line formula is $Y = 15.51 + 23.11\,X$; $r = 0.8664$, $n = 18$, $P < 0.001$.

O'DONOGHUE (1927: 90) and MACFARLAND (1966: 154 - 155) have described the morphology of the teeth. The rachidian is small and triangular-shaped (Figure 7-A). The innermost lateral teeth have 3 - 4 main denticles on the inner face of the shaft, 3 - 6 small ridge-like denticles on the inner side of the cusp, and 4 - 5 denticles on the outer face of the shaft (Figure 37). Lateral teeth in the middle of each half-row have a prominent cusp and numerous denticles (10 - 16) on the posterior surface of the shaft (Figure 38). The outer lateral teeth (Figures 7-B, 7-C, 39) become smaller, with a greatly reduced cusp.

Developing lateral teeth (Figure 40) are thin and narrow, with weak cusps and needle-like denticles.

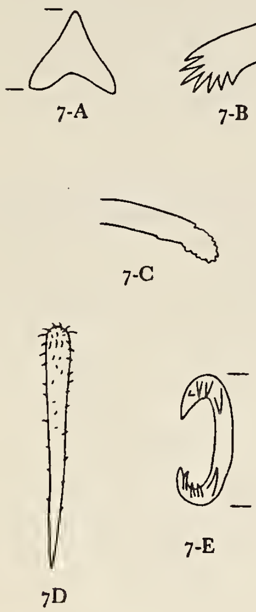


Figure 7

Chromodoris mcfarlandi

radular teeth and sponge spicules found among the teeth

A – HB 393; rachidian tooth; LBM, 0.02 mm

B – HB 394; lateral view of distal portion of 5th tooth from outer edge of radula (prominent cusp does not occur on the outermost teeth); approximately row 31, RSR

C – HB 394; 3rd tooth from outer edge of radula; row 25, LSR

D – HB 414 A; sponge spicule (0.071 mm long) found on radula

E – HB 455; sponge spicule (monaxon, recurved ends with accessory points) found on radula; LBM, 0.04 mm

Discussion:

Sponge spicules (Figures 7-D, 7-E) were found under the teeth in 2 radulae. BLOOM (1976: 294) reports that

Explanation of Figures 33 to 38

Scanning Electron Micrographs of the Radular Teeth of *Chromodoris galexorum* and *Chromodoris mcfarlandi*

Figure 33: *Chromodoris **galexorum***; rachidian and innermost lateral teeth (specimen HB 256) × 775

Figure 34: *Chromodoris **galexorum***; inner lateral teeth (HB 256) × 1300

Figure 35: *Chromodoris **galexorum***; lateral teeth from middle and outer portions of half-row (HB 256) × 275

Figure 36: *Chromodoris **galexorum***; cusps and distal portion of teeth from middle of half-row (HB 256) × 800

Figure 37: *Chromodoris mcfarlandi*; innermost lateral teeth (HB 253 C) × 1975

Figure 38: *Chromodoris mcfarlandi*; lateral teeth from middle of half-row (HB 253 C) × 1650

Figure *33*

Figure *34*

Figure *35*

Figure *36*

Figure *37*

Figure *38*

Chromodoris mcfarlandi feeds on sponges from the genera *Gellius* and *Haliclona*.

Chromodoris mcfarlandi is a beautiful nudibranch, immediately identifiable by its coloration and the large numbers of denticles on the lateral teeth in the middle of the half-rows. It is a fitting tribute (even though the name is misspelled) to Prof. MacFarland and his magnificent detailed work on Californian nudibranchs.

Chromodoris norrisi Farmer, 1963

(Figures 3-E, 8, 13 - 15, *41 - 46*)

References and Synonymy:

Chromodoris norrisi FARMER, 1963: 81 - 84; plt. 1 a; text figs. 1 a-e. MARCUS & MARCUS, 1967: 170 - 173; figs. 21 - 23 (Material 1 only); 237 - 238. FARMER, 1968: 24 - 25, VII. EV. MARCUS & ER. MARCUS, 1970: 198. BERTSCH, 1970: 8, 12; fig. 3. BERTSCH, 1971: 16. KEEN, 1971: 822, fig. 2331; plt. 20, fig. 4. Farmer, 1971: 19. Sphon, 1972b: 59. BERTSCH *et al.*, 1973: 292 - 293. BERTSCH, 1973: 108. BRUSCA, 1973: 174. BERTSCH, 1975: 105. BERTSCH, 1976b: 157

Glossodoris norrisi (Farmer). ABBOTT, 1974: 355; fig. 4246

Material Examined and Distribution:

Baja California, Gulf Coast:

1) 1 specimen, Bahía de Los Angeles; *leg.* J. Lance, April 1968 (identified from a color transparency)

2) 1 specimen, subtidal, Notri (13 km S of Loreto); *leg.* H. Bertsch, M. Ghiselin, & J. Allen, 4 July 1974 (HB 95)

3) 2 specimens, intertidal, Juncalito (19 km S of Loreto); *leg.* H. Bertsch and B. Rose, 24 December 1973 (HB 40 A-B)

4) 5 specimens, subtidal 2 - 3 m, Nopolo and Juncalito; *leg.* H. Bertsch, M. Ghiselin, & J. Allen, 27 June 1974 (HB 85 A-E)

5) 1 specimen, subtidal 1.5 - 3 m, N end of Isla Santa Cruz; *leg.* D. Chivers, 26 June 1964 (HB 448; CAS)

6) 3 specimens, 14 m subtidal, S end of Isla San Diego; *leg.* E. Janss, Jr., April 1974 (LACM)

7) 5 specimens, intertidal on mangrove roots, Isla San Jose; *leg.* G. G. Sphon, 2 April 1974 (LACM)

8) 1 specimen, Caleta San Evaristo, Isla de San Francisco; *leg.* G. G. Sphon, 1 April 1974 (LACM)

9) 1 specimen, 6 m subtidal, Piedra del Saltito, 6 km S of Puerto Mejía, La Paz; *leg.* A. J. Ferreira, 12 June 1974 (HB 376)

10) 7 specimens, 1 - 3 m subtidal, Bahía Carisalito (4 km N of Las Cruces); *leg.* H. Bertsch, T. Cooke, & G. Stellern, 26 July 1972 (HB 15 A-G)

11) 4 specimens, Las Cruces; *leg.* H. Bertsch, 1 - 18 July 1969 (HB 68 - 71)

12) 4 specimens, Las Cruces; *leg.* H. Bertsch, 1 July 1974 (HB 92 A-B, 93, 94)

13) 6 specimens, 1.5 - 10 m subtidal, N of Punta Gorda, 8 km S of Las Cruces; *leg.* H. Bertsch, 22 July 1972 (HB 14 A-F)

14) 1 specimen, N end of Isla Cerralvo; *leg.* H. Bertsch, 29 July 1969 (HB 72)

15) 1 specimen, subtidal, SW Isla Cerralvo; *leg.* H. Bertsch, 25 July 1972 (HB 19)

Mainland Mexico, Gulf Coast:

16) 1 specimen, intertidal, Puerto Peñasco, Sonora; *leg.* H. Bertsch, 24 December 1975 (HB 344)

17) 2 specimens, intertidal, Puerto Peñasco, Sonora; *leg.* H. Bertsch, 26 and 29 December 1975 (HB 350 A-B)

18) 3 specimens, rocky intertidal, Guaymas, Sonora; *leg.* A. Kerstitch, 30 July 1966 (HB 323 A-C; USNM 753561)

19) 2 specimens, Puerto Peñasco and Guaymas, Sonora; *leg.* P. Pickens & M. A. Hill, 7 August 1964 and 28 June 1965 (HB 322 A-B; USNM)

The type locality of *Chromodoris norrisi* is Isla Cerralvo, The animal has been collected from the outer coast of Baja California and numerous localities within the Gulf of California (summarized in BERTSCH *et al.*, 1973: 292 to 293); the known range along the Gulf coast of Baja California is from Bahía San Luis Gonzaga to SW Isla Cerralvo; it has been reported from Puerto Peñasco to Guaymas along Mainland Mexico.

Lot 6 represents a new bathymetric range for this species.

External Morphology and Coloration:

Large specimens of living *Chromodoris norrisi* will reach 61 mm (FARMER, 1963: 83). Between 1 - 19 July 1969, 22 - 26 July 1972, and 27 June - 4 July 1974, 28 specimens collected near Loreto and Las Cruces varied from 21 - 50 mm long alive ($\overline{X} = 33.5$, $s = 8.66$). Six specimens collected during winter and early spring (24 December 1973, Loreto area; 24 December 1975, Puerto Peñasco; April 1968, Bahía de Los Angeles) varied from 4 - 12 mm total length alive ($\overline{X} = 8.7$, $s = 2.66$). There is a significant difference ($t = 6.867$, $P < 0.001$) between these 2 seasonal groups, that hints at possible population cycles within the Gulf of California. As water warms in spring and summer, the animals grow to reproductive size, copulate and lay eggs. Settling of larvae may occur twice (in early summer and early autumn), with rapid summer growth and F_1 reproducing late summer. Those hatching in autumn metamorphose and are the smaller individuals found during winter. A year-round study (with biweekly or monthly sampling) is needed to test this hypothesis.

Body background color is white. Some specimens show a violet coloration in the middle of the dorsum that is sub-epidermal in origin (FARMER, 1963: 81). The notum and lateral and posterior surfaces of the foot have numer-

Table 5

Radular variation in *Chromodoris norrisi*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
6	–	–	–	65	44
7	–	–	–	68	48
14 A	3.39	1.74	1:1.95	68	58
14 B	3.29	1.58	1:2.08	69	52
14 C	3.84	1.86	1:2.06	71	58
14 E	3.58	1.88	1:1.9	74	63
14 F	3.696	1.96	1:1.89	71	60
15 A	3.11	1.62	1:1.92	76	58
15 B	3.8	1.8	1:2.1	75	64
15 C	3.15	1.76	1:1.79	70	56
15 D	4.02	2.22	1:1.81	80	62
15 E	2.83	1.82	1:1.55	67	62
15 F	3.37	2.0	1:1.69	68	59
15 G	3.47	1.74	1:1.99	68	56
19	–	–	–	65	54
40 A	0.76	0.299	1:2.54	36	25
40 B	1.13	0.57	1:1.98	50	40
68	3.92	2.08	1:1.88	71	55
69	4.1	2.1	1:1.95	73	61
70	4.55	2.32	1:1.96	85	67
71	3.66	1.76	1:2.08	65	62
72	3.9	1.9	1:2.05	76	62
85 A	4.6	2.16	1:2.13	86	71
85 B	3.72	1.96	1:1.9	67	52
85 C	3.96	2.2	1:1.8	79	63
85 D	3.7	2.08	1:1.78	69	55
85 E	2.95	1.53	1:2.06	64	51
92 A	4.06	2.22	1:1.83	79	67
92 B	4.24	2.3	1:1.84	76	69
93	3.9	2.02	1:1.93	68	58
94	3.76	2.22	1:1.69	74	56
95	4.44	1.94	1:2.29	83	56
322 A	2.08	1.35	1:1.54	69	55
322 B	1.15	0.77	1:1.49	49	38
323 A	3.37	1.9	1:1.77	80	66
323 B	3.64	2.08	1:1.75	97	72
323 C	3.01	1.86	1:1.62	77	58
344	1.07	0.57	1:1.88	48	39
350 A	2.02	0.87	1:2.32	51	37
350 B	1.74	1.01	1:1.72	53	40
$\overline{X}$	3.26	1.73	1:1.905	69.5	55.725
s	1.015	0.525	0.217	11.59	10.233

[6]MARCUS & MARCUS, 1967; [7]FARMER, 1963

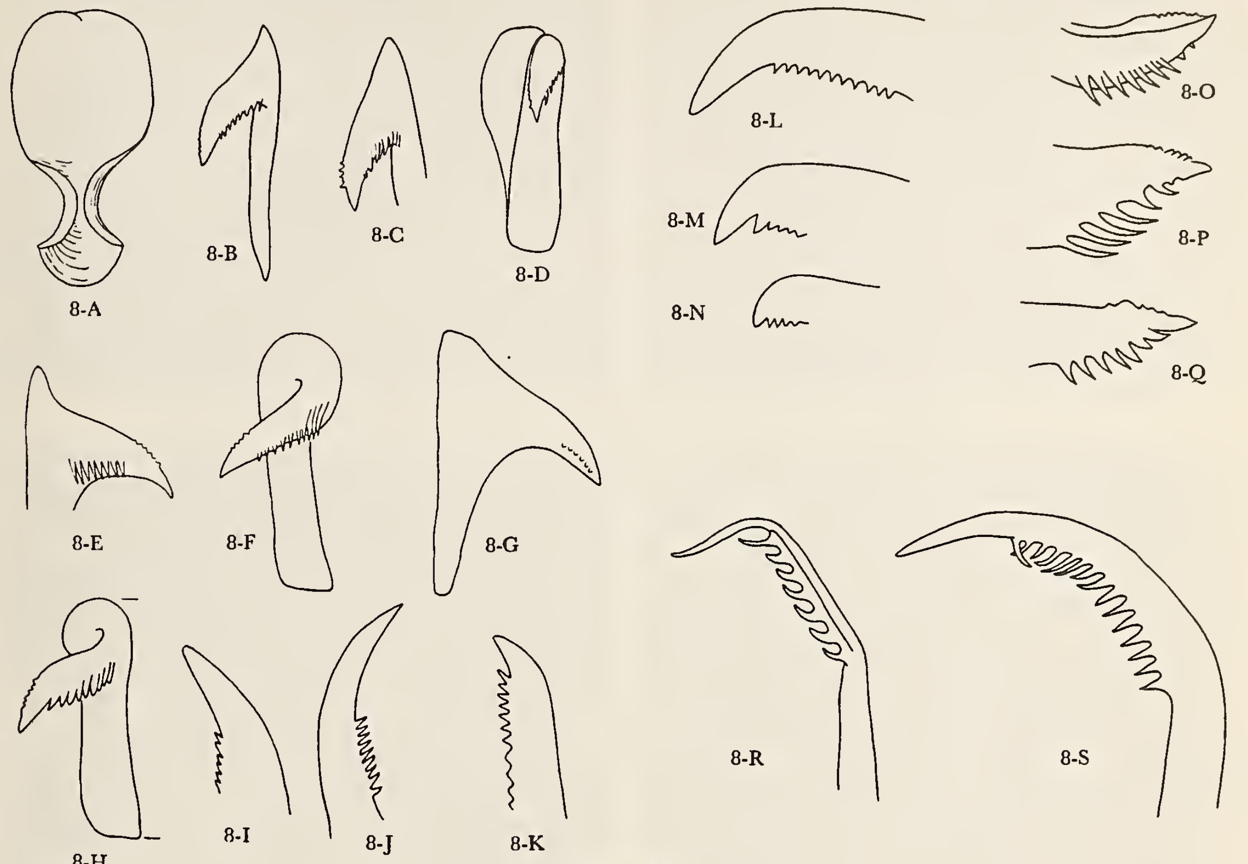


Figure 8

Radular teeth of *Chromodoris norrisi*

A – HB 40 B; outline sketch of entire radula prior to flat-mounting
B – HB 14 A; dorso-lateral view of 2^{nd} tooth, row 55, RSR
C – HB 14 A; 3^{rd} lateral tooth, row 55, RSR
D – HB 14 A; 5^{th} lateral tooth, row 55, RSR; adjacent inner tooth overlaps the lateral basal flange
E – HB 14 A; outer face of 4^{th} lateral tooth, row 60, LSR
F – HB 14 F; 2^{nd} tooth, row 64, RSR
G – HB 69; inner face of 5^{th} tooth, row 66, RSR
H – HB 15 B; dorso-lateral view of 5^{th} lateral tooth, row 74, RSR; LBM, 0.057 mm
I – HB 323 B; distal portion of shaft, tooth 28, approximately row 30
J – HB 15 B; distal portion of shaft, tooth 26, row 69, LSR
K – HB 323 B; distal portion of shaft, 5^{th} tooth from outer edge of radula, approximately row 32
L – HB 323 C; approximately tooth 13, row 28
M – HB 323 C; 10^{th} tooth from outer edge of radula, row 28
N – HB 323 C; 5^{th} tooth from outer edge of radula, row 28
O – HB 14 A; distal shaft of developing 1^{st} lateral tooth, last row, LSR (outer face with heavier denticulation)
P – HB 14 A; distal shaft of developing 3^{rd} lateral tooth, last row, LSR
Q – HB 14 A; distal shaft of developing 4^{th} lateral tooth, last row, LSR
R – HB 14 A; shaft of developing lateral tooth, approximately $\frac{1}{4}$ the distance from radular outer edge to center of radula; last row, RSR
S – HB 14 B; shaft of developing 27^{th} lateral tooth, drawn to same scale as Figure 8 R; last row, RSR

ous small red dots; the notum also has about $\frac{1}{2}$ as many yellow dots. A bright orange broken band encircles the edge of the notum. There is a wide range of variation in the number and size of the dots from very many small ones to fewer, larger spots (Bertsch *et al.*, 1973: 293). Color photographs appear in Farmer (1963; plt. 1a) and Keen (1971: plt. 20, fig. 4).

Radula:

Farmer (1963) and Marcus & Marcus (1967) have

published radular formulae of *Chromodoris norrisi.* Although Farmer gives a range of variation for 6 specimens, he only gives the holotype formula separately. This is the only count from Farmer's paper that can be analyzed statistically. Table 5 presents the individual radular sizes and counts of the 2 published radular formulae and the 38 radulae I examined. The new combined radular formula is 36-111 (25-72 · 1 · 25-72).

Least squares regression analysis shows that the number of tooth rows and maximum number of teeth per half-row are positively correlated (Figure 13). The equation, $Y = -0.147 + 0.804 X$, describes the regression line. The coefficient of correlation is 0.9106 ($P < 0.001$, $n = 40$).

The number of tooth rows is positively correlated with the radular length (Figure 14). The regression line formula is $Y = 36.84 + 10.07X$, and $r = 0.8513$ ($P < 0.001$, $n = 37$).

The radular width and maximum number of teeth per half-row (Figure 15) are positively correlated, with $r = 0.8965$. The formula describing the regression line is $Y = 25.7 + 17.7 X$ ($P < 0.001$, $n = 37$).

Figure 8-A is an outline sketch of the entire radula; the smaller posterior portion has not been flattened. The innermost lateral tooth has approximately 5 inner and 5 outer denticles. Inner lateral teeth have a thick, squat shaft, with 4 - 9 denticles on the outer face (Figures *41* and *42*). Toward the middle region of the half-row, the teeth become longer with more erect shafts. The denticles change from thick lateral structures to pointed prongs (7 - 14 in number) on the posterior surface of each tooth, and the cusp becomes quite prominent (Figures 8I - 8L). Towards the outer margin the teeth are reduced in size, and cusps and denticles become smaller (Figures 8M, 8N, *43*). Denticles on the outer and posterior surfaces averaged 8.19 across a half-row ($n = 32$; of the 66 teeth in the half-row, only half were lying in such a way as to allow denticle counts).

The length of the cusps across a half-row averaged 0.0154 mm (range, 0.006 - 0.022 mm, $n = 53$). The mean ratio of the length of the first denticle to the length of the cusp is 1:4.517 (range from 1.17 on the extreme ends of the half-row to 11 in the central region of the half-row; $s = 2.42$, $n = 53$).

The radulae of 18 specimens (47% of the *Chromodoris norrisi* radulae dissected for this study) had a double-denticulation pattern on the first 2 - 9 innermost teeth (Figures 8B - 8H). In addition to denticles on the outer face of the shaft, these teeth had 2 - 8 denticles on the inner face of the cusp ($\overline{X} = 5.1$, $n = 45$). This is the same as the double-denticulation pattern described for the first 4 lateral teeth of *C. sphoni. Chromodoris norrisi* specimens 14 A, E, F, 15 B, had an average of 6.7 double-denticled teeth ($n = 39$) on each half-row in the posterior 16, 6, 7, and 6 rows respectively. This pattern was not visible in the anterior half of the radulae.

Patterns of tooth growth are shown in Figures *44* and 8-O to 8-S (progressing from the innermost laterals to teeth nearer the middle of the half-row). The early development of the central lateral teeth is from thin shafts with just the hint of posterior denticulation (Figure *45*) to stronger shafts with needle-like denticles (Figure *46*). The scanning electron micrographs (Figures *41* - *46*) offer an immediate visual comparison of developing and fully-formed teeth.

Discussion:

Chromodoris norrisi is readily separated from the related *C. baumanni.* Visual examination of their radulae reveals immediate perceptual differences. The cusps of the middle lateral teeth of *C. norrisi* are longer and more pronounced than the *C. baumanni* cusps (compare Figures 8-I to 8-K with Figures 4-H, 4-I). This gestalt impression can be proved statistically. The length ratio of the first denticle:cusp is significantly different (longer) for *C. norrisi* than *C. baumanni* ($t = 5.78$, $P < 0.001$, D.f. $= 78$). The absolute cusp lengths of *C. norrisi* teeth are significantly different from (longer than) *C. baumanni* ($t = 7.042$, $P < 0.001$, D.f. $= 77$). Other radular differences are treated in Discussion of *Chromodoris*; color differences are summarized in BERTSCH, 1970: 12; fig. 3).

Explanation of Figures *39* to *44*

Scanning Electron Micrographs of the Radular Teeth
of *Chromodoris mcfarlandi* and *Chromodoris norrisi*

Figure *39*: *Chromodoris mcfarlandi*; outermost lateral teeth (HB 253 C) × 2475

Figure *40*: *Chromodoris mcfarlandi*; developing lateral teeth, innermost teeth at upper left (HB 253 C) × 825

Figure *41*: *Chromodoris norrisi*; rachidian area and innermost lateral teeth (HB 376) × 825

Figure *42*: *Chromodoris norrisi*; 3 innermost lateral teeth (enlargement of Figure *41*) (HB 376) × 2300

Figure *43*: *Chromodoris norrisi*; outermost lateral teeth (HB 376) × 825

Figure *44*: *Chromodoris norrisi*; developing rachidian and innermost lateral teeth (HB 376) × 825

Figure 39

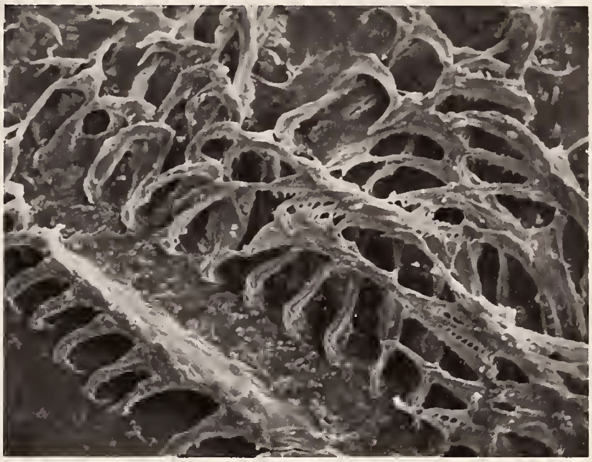


Figure 40

Figure 41

Figure 42

Figure 43

Figure 44

THOMPSON (1972: 401) suggests that *Chromodoris norrisi* is merely a subspecies of *C. amoena* Cheeseman, 1886. I cannot agree with this; *C. norrisi* is similar to *C. amoena*, but shows important characteristics that warrant full specific status. The coloration of *C. amoena* has many irregular orange blotches with a few irregular purple blotches. This is the opposite pattern of *C. norrisi*, where purple dots (quite regularly circular, not irregular) are at least twice as numerous as the yellow (not orange) dots. Under the mantle of *C. norrisi* are purple spots, not orange. The gills of *C. norrisi* are orange distally, not completely red. RUDMAN (1973) has commented on the usage of color patterns. The differences between *C. amoena* and *C. norrisi* are not just subtle color tints, but entire pattern differences. MARCUS & MARCUS (1967: 173) summarized radular differences (absolute numbers of teeth per half-row and tooth denticles) between the 2 species. The proportion between the numbers of tooth rows and maximum number of teeth per half-row is also important. *Chromodoris amoena* has a greater number of teeth per half-row than of tooth rows; the opposite characterizes *C. norrisi.* Although these 2 species show similarities, they are separate species, each with its own distinctly different range of variation.

Chromodoris sphoni (Marcus, 1971), *comb. nov.*

(Figures 3-F, 9, 10 - 12)

References and Synonymy:

Felimida sphoni MARCUS, 1971: 355 - 357; figs. 1 - 3. ANONYMOUS, 1972: 11; color photograph. SPHON, 1972b: 64. BERTSCH *et al.*, 1973: 292, 293. MARCUS & HUGHES, 1974: 520. KEEN & COAN, 1975: 43. BERTSCH, 1976b: 158

Chromodoris sphoni (Marcus). BERTSCH & MEYER, in prep.

Material Examined and Distribution:

Mainland Mexico and Central America:

1) 1 specimen, 3m subtidal, SE Isla Venado, Mazatlán, Mexico; *leg.* A. J. Ferreira, March 1971 (HB 420; LACM)

2) 3 specimens, intertidal, Punta Mita, Nayarit, Mexico; *leg.* F. & R. Poorman, 2 January 1976 (HB 422 A-C; LACM)

3) 1 specimen, 2m subtidal, Puerto Angel, Oaxaca, Mexico; *leg.* A. J. Ferreira, December 1971 (HB 421; LACM)

4) 1 specimen, Islas Tortugas, Costa Rica; R/V *Searcher*, 440 (no additional data) (HB 419; LACM)

5) 2 specimens, Taboguilla Island, Panamá Bay, Panamá; *leg.* G. Hendler, 11 September 1974 (HB 217, 218)

6) 1 specimen, Taboguilla Island, Panamá; *leg.* G. Hendler, 1 October 1974 (HB 266)

All the records of *Chromodoris sphoni* are from the mainland Pacific coast of Mexico and Central America, from the Mazatlán area to Panamá Bay. The type locality was never designated; the original material came from 2 localities about 300km apart in the Mexican states of Nayarit and Colima.

External Morphology and Coloration:

Living *Chromodoris sphoni* from Panamá were 11 and 7mm in total length; their preserved lengths were 4.5 and 3mm long, respectively. MARCUS (1971: 357) described preserved specimens 18, 16, 15, 15, and 8mm long. The other 7 specimens I dissected ranged in length from 4 to 15mm preserved ($\bar{X} = 6.7$mm). Average-sized living animals are probably 10 - 20mm long, with a maximum size of 30 - 40mm.

Characteristic of *Chromodoris sphoni* is a red-cross pattern on its notum (color photograph in ANONYMOUS, 1972). The overall coloring is described by MARCUS (1971: 356 - 357). Small specimens from Panamá (HB 217, 218) had the prominent longitudinal red band between the rhinophores and gills, and the lateral red bar from edge to edge of the notum. The rest of the animal was cream-yellow, with a bar of red running lengthwise on each side of the notum; a red band surrounded the mantle edge. The red markings were punctuated and rimmed by rows of small whitish dots. The smaller specimen (7mm; HB217) had only a partial lengthwise red band on each side of the notum; the small markings were strongest adjacent to the lateral red bar, fading out anteriorly and posteriorly. This marking develops into a longer line with increased growth of the animal. Both of these specimens had only faint greenish markings, and an overall light coloration. Gills and rhinophores were white basally and pink-red distally.

Radula:

The radular formula from only one specimen has been described in the literature (MARCUS, 1971), and it is aberrant from the radular counts obtained from 9 specimens (Table 6). The combined radular formula is 40-59 (26-60 · 1 · 26-60).

The numbers of tooth rows and maximum teeth per half-row are positively correlated (Figure 10). The regression line formula is $Y = -20.19 + 1.131\ X$; ($r = 0.5688$, $P < 0.01$, $n = 10$).

The number of tooth rows is dependent on the radular length (Figure 11); $Y = 26.23 + 16.896\ X$; $r = 0.921$, $P < 0.001$, $n = 9$.

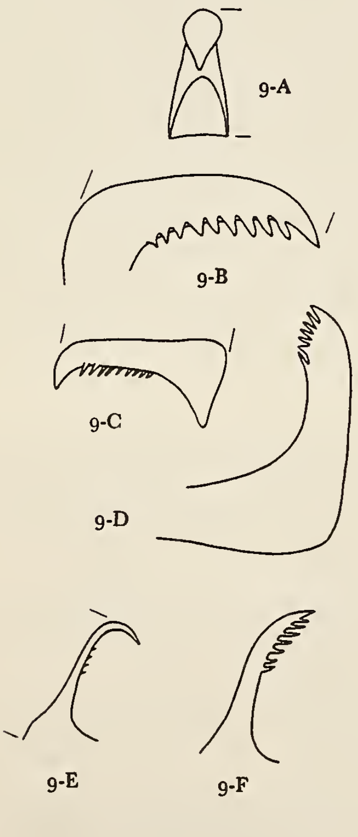
The radular width and maximum number of teeth per half-row are positively correlated (Figure 12). The formula is $Y = 16.99 + 24.58\ X$; $r = 0.907$, $P < 0.001$, $n = 9$.

Table 6

Radular variation in *Chromodoris sphoni*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
*	–	–	–	58	60
217	0.776	0.307	1:2.53	40	26
218	0.929	0.404	1:2.3	42	26
266	1.09	0.48	1:2.27	40	27
419	1.551	0.808	1:1.92	54	36
420	1.058	0.566	1:1.87	45	33
421	1.172	0.654	1:1.79	42	28
422 A	1.58	0.91	1:1.74	54	41
422 B	1.92	0.71	1:2.7	59	37
422 C	0.865	0.331	1:2.61	45	26
$\overline{X}$	1.216	0.57	1:2.19	47.9	34
s	0.384	0.212	0.372	7.535	10.625

*Marcus, 1971



Rachidian tooth is present (Figure 9-A). At times it may be a triangular plate with a slightly raised median cusp and without the basal flanges. Innermost laterals are standard *Chromodoris*-shape, but with small denticles on the inner face of the cusps of lateral teeth 1 - 4. These denticles may not always be obvious in the anterior portion of the radula. Lateral teeth (Figures 9-B, 9-C) have prominent cusps and are greatly denticulated (Marcus, 1971, reported up to 17 - 19 denticles). Outermost laterals become smaller, with greatly reduced cusps.

Two stages in the development of lateral teeth are shown in Figures 9-E, 9-F.

Scanning electron micrographs of the radula and drawings of the reproductive system are in Bertsch & Meyer (in preparation).

Discussion:

Marcus (1971) erected a new genus for this species, because of the unique double-denticulation pattern. How-

(← adjacent column)

Figure 9

Radular teeth of *Chromodoris sphoni*

A – HB 217; rachidian tooth; LBM, 0.024 mm
B – HB 266; 12[th] lateral tooth, row 26, LSR
C – HB 217; 14[th] lateral tooth, row 32, RSR; LBM, 0.026 mm
D – HB 266; outer lateral tooth, row 11, LSR
E – HB 266; newly forming tooth, row 40; thin shaft with minute, sharply-pointed denticles; LBM, 0.032 mm
F – HB 266; shaft of developing tooth, 0.034 mm long, row 40

ever, examination of a large number of radulae indicates that this characteristic is present at times in other species (*i. e., Chromodoris galexorum* and *C. norrisi*). The strength and size of these inner-face denticles vary, as does also the number of laterals exhibiting the pattern. Because the double-denticulation can be present or absent in other species, and (perhaps more importantly) because it is a relatively minor morphological character trait that does not affect major portions of the radula nor indicate a major functional (nor evolutionary) divergence, and because it is an inconsistent structure, justification is lacking for the retention of a separate genus to encompass *C. sphoni*.

Therefore, *Felimida* is a junior synonym of *Chromodoris* and the species should be referred to as *Chromodoris sphoni*. Double-denticulation on the first 8 lateral teeth (usually less than 10 - 15% of the total teeth per half-row) is part of the variation that may occur in the genus *Chromodoris*.

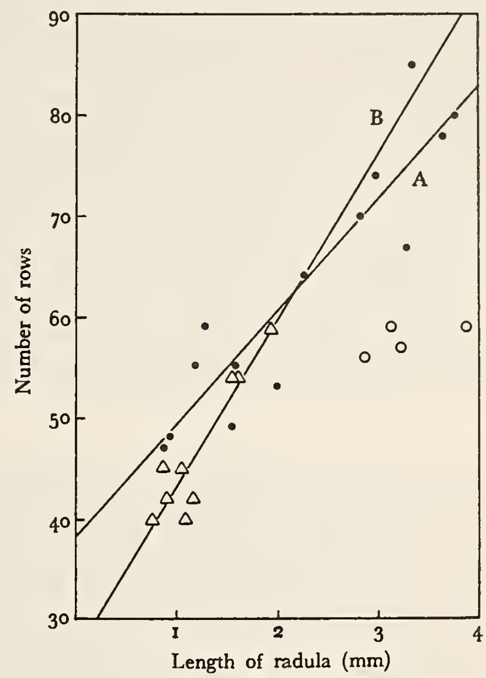


Figure 11

Correlation between number of rows and length of radula *Chromodoris baumanni*, *Chromodoris sphoni* and *Chromodoris galexorum*. Same symbol explanations as in Figure 10

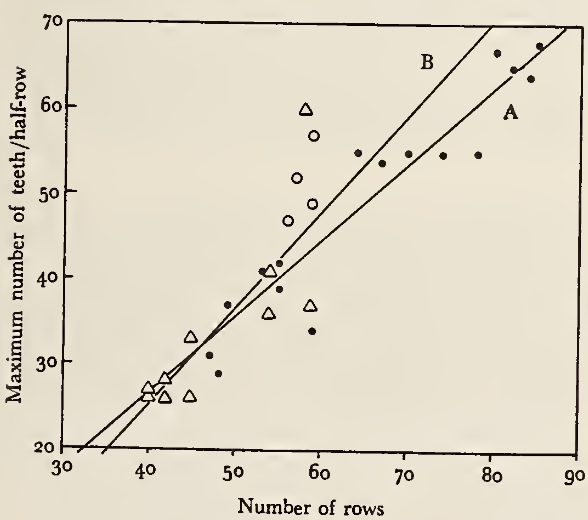


Figure 10

Relation between maximum number of teeth per half-row and the number of tooth rows

A – *Chromodoris baumanni* regression line

B – *Chromodoris sphoni* regression line

●: *C. baumanni*; △: *C. sphoni*; ○: *C. galexorum*

Regression formulae for the plots of all graphs are given in the text

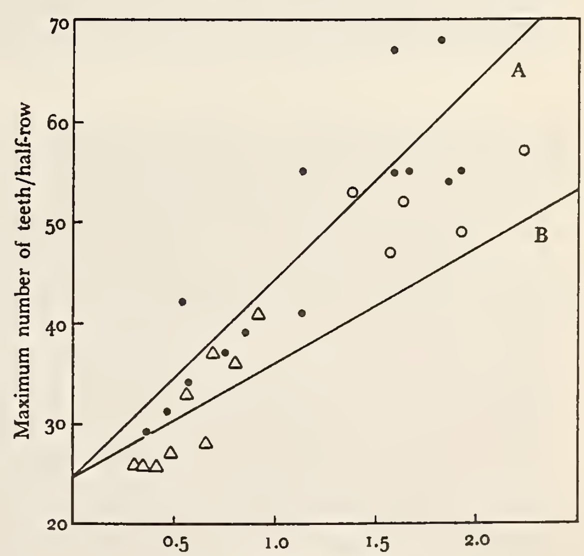


Figure 12

Relation between maximum number of teeth per half-row and width of radula, *Chromodoris baumanni*, *C. sphoni*, and *C. galexorum*. Same symbol explanations as in Figure 10